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28OCT99 E487622-1 C2755
P01/7700 0.00 - 9925486.4

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1. Your reference — pre.683.uk.nmck2

2. Patent applicat... (The f... — 9925486.4 — 28 OCT 1999

3. Full n..., address and postcode of the or of each applicant *(underline all surnames)* — Preston Associates (Scotland) Limited
4 North Approach Road
KINCARDINE ON FORTH
FK10 4NH
United Kingdom

Patents ADP number *(if you know it)* — UK 7769193001

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention — Plastic stretching method and apparatus for use in vacuum forming techniques

5. Name of your agent *(if you have one)* — Kennedy & Co.
Floor 4, Queen's House
29 St Vincent Place
GLASGOW
G1 2DT
United Kingdom

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Patents ADP number *(if you know it)* — 7283344002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
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No

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Continuation sheets of this form	
Description	10
Claim(s)	9
Abstract	
Drawing(s)	4

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Kennedy & Co
KENNEDY & CO.

Date 28/10/99

12. Name and daytime telephone number of person to contact in the United Kingdom

Neil McKechnie
tel: 0141 226 6826

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PLASTIC STRETCHING METHOD AND APPARATUS FOR USE IN VACUUM FORMING TECHNIQUES

The present invention relates in general to technology for stretching plastic sheets. In particular, the invention relates to the stretching of plastic sheets as a preparation step for use with vacuum forming techniques.

Vacuum forming techniques are used in a variety of industries; for example, bathroom furnishings such as baths can be vacuum formed from a single sheet of thermoplastic material. The thermoplastic material most commonly used for vacuum forming bathroom furnishings at the present time is acrylic.

In this manufacturing process, the cost of the thermoplastic sheet represents approximately 70% of the manufacturer's final costs. It would therefore be beneficial to find a method of using less thermoplastic in the manufacturing process. However, if one simply used a thinner sheet, one would expect to produce a final product with reduced mechanical strength.

It is therefore an aim of the present invention to provide a method and apparatus for producing vacuum formed goods that uses less thermoplastic than conventional techniques whilst retaining, or even improving, mechanical strength.

We have found that a thermoplastic sheet, such as an acrylic sheet, which has been stretched before vacuum forming provides a final product which has greater mechanical strength than an unstretched sheet which has the same thickness at the start of the vacuum forming step.

However, when one considers how to implement this stretching step industrially, a technical difficulty becomes apparent. When a plastic sheet is stretched it will scallop, that is to say that it will narrow in the middle with the sides bowing inwards. This means that it will not have a constant width and thickness throughout and cannot be cut efficiently into smaller square or rectangular portions.

The aim of this invention is therefore to provide a method of stretching plastic sheets which can be used to expand the total surface area of the sheet without distorting the sheet, wasting material or having a non-uniform thickness. In particular, this invention aims to stretch the plastic sheet in a manner adapted for immediate use in vacuum forming to gain the strength enhancing benefits of the stretching step.

In this application, the term "plastic" refers to any thermoplastic material.

According to the present invention there is provided a machine for stretching a rectangular sheet of plastic material, the machine having a first and second orthogonal pairs of opposed clamping means which engageably cooperate with the sides of said sheet and thereby hold said sheet, the machine including a means to controllably urge apart a first pair of opposed clamping means and thereby stretch a sheet held therein, the second pair of clamping means being adapted to allow said sheet to stretch uniformly in the direction in which it is stretched whilst resisting movement of the sides of said sheet in a direction orthogonal to the direction in which it is stretched.

Preferably, the machine includes means to controllably urge apart both pairs of opposed clamping means and thereby stretch a sheet held therein in two dimensions, both pairs of clamping means are adapted to allow said sheet to stretch uniformly parallel to the direction of stretching whilst resisting movement of the sides of said sheet orthogonally to the direction of stretching.

Preferably also, the machine is adapted to stretch the sheet first in one direction and then subsequently in a second direction orthogonal to the first direction.

Preferably, the clamping means are elongate and each comprise a plurality of secondary clamps which engageably clamp a portion of the sheet of plastic material. More preferably, the secondary clamps are adapted to move along the length of the clamping means proportionately to the stretching of the sheet parallel to the length of the clamping means.

Most preferably, the secondary clamps are moved along the length of the clamping means proportionately to the stretching of the sheet by the motion of said sheet.

Preferably, the clamping means further comprise a primary clamping means which engageably and fixedly clamps a side of the sheet of plastic material.

More preferably, the machine is adapted to vacuum form a plastic sheet held within the clamping means.

Preferably also, the machine comprises a heating means for evenly heating a plastic sheet held therein.

According to a second aspect of the present invention there is provided a method of stretching a rectangular sheet of plastic material, the method comprising the steps of:

(a) engagably holding the sides of said sheet; and
(b) stretching said sheet along a first axis of said sheet whilst holding the sides of said sheet parallel to the first axis so as to allow the sheet to stretch uniformly along the first axis but so as to resist deformation of the sides of said sheet orthogonal to the first axis.

Preferably, the method further comprises the step of stretching said sheet along a second axis of said sheet whilst holding the sides of said sheet parallel to the second axis so as to allow the sheet to stretch uniformly along the second axis but so as to resist deformation of the sides of said sheet orthogonal to the second axis, wherein the second axis is orthogonal to the first axis.

Preferably, the machine includes means to controllably urge apart both pairs of opposed clamping means and thereby stretch a sheet held therein in two dimensions, both pairs of clamping means are adapted to allow said sheet to stretch uniformly parallel to the direction of stretching whilst resisting movement of the sides of said sheet orthogonally to the direction of stretching.

Preferably, the sides of said sheet are engageably held by a first and second orthogonal pairs of clamping means which each engageably cooperate with a side of said sheet.

More preferably, said sheet is stretched along a first axis by a means to controllably urge apart a first pair of opposed clamping means and thereby stretch a sheet held therein, the second pair of clamping means being adapted to allow said sheet to stretch uniformly in a direction parallel to the clamping means whilst resisting movement of the sides of said sheet in a direction orthogonal to the clamping means.

Preferably, the clamping means comprises a plurality of secondary clamps which engageably clamp a portion of the sheet of plastic material.

More preferably, the secondary clamps are adapted to move along the length of the clamping means proportionately to the stretching of the sheet along an axis parallel to the clamping means.

Most preferably, the secondary clamps are moved along the length of the clamping means proportionately to the

stretching of the sheet along an axis parallel to the clamping means by the motion of said sheet.

Preferably, the method further comprises the step of engageably and fixedly clamping the sides of the sheet of plastic material with a plurality of primary clamping means.

Preferably also, the method includes the step of evenly heating the sheet of plastic material.

According to a third aspect of the present invention, there is provided a method of vacuum forming a sheet of plastic material comprising the steps of stretching a sheet of plastic material according to the second aspect above and then vacuum forming said sheet of plastic material.

An example embodiment of the present invention will now be illustrated with reference to the following figures in which:

Figure 1 is a plan view of a plastic sheet stretching machine;

Figure 2 is a cross-section through a plastic stretching machine along line AA;

Figure 3 is a perspective view of a plastic stretching machine according to the present invention; and

Figure 4 shows a plan for cutting up sheets of material in a conventional fashion and in a fashion for use with the present invention.

A plastic stretching machine is intended for use with a rectangular sheet of plastic material or any other vacuum

formable material. Four clamping bars are provided, one to clamp each edge of the rectangular plastic sheet. Clamping bars 1 and 3 oppose each other, as do clamping bars 2 and 4. Clamping bars 1 and 2 are fixed in place, whereas clamping bars 3 and 4 may be moved, as controlled by a programmable logic controller.

Each clamping bar 1, 2, 3 and 4 comprises a plurality of secondary clamping means 5 (only some of which are labelled in Figure 1). These clamping means are mounted upon each clamp bar and may move along its length with a low co-efficient of friction.

A rectangular hot thermoplastic sheet is placed within the device and is clamped around its four edges by the secondary clamps 5. This apparatus is shown in cross-section along line AA in Figure 2.

Actuator 6 activates the clamping mechanism. This causes the clamping head to be rotated around joint 7 on support assembly 8 and the plastic sheet is held in the secondary clamps 5 between plates 9 and 10. Alternate pairs of clamp bars are then pulled apart. For example, whilst clamp bar 1 is held in place, clamp bar 3 may be moved away from it, stretching the plastic sheet in the longitudinal direction. Clamp bars 2 and 4 do not move. However, the secondary clamps 5 are free to move along the clamp bars. They are pulled along by the material sheet and therefore move proportionately to the movement of clamp bar 3. They act to resist scalloping of the plastic sheet.

Similarly, clamp bar 4 can be moved away from clamp bar 2, whilst clamp bar 1 and clamp bar 3 remain in place.

Again, the clamping means move proportionately to the stretching of the sheet cause by movement in clamping bar 4 and prevent scalloping. In order for this to work there has to be very low friction preventing the movement of the secondary clamping means.

Once the stretching phase has been completed, an actuator 11 acting through a thrust pin 12 engages a primary clamping means which is provided on each clamped set and comprises a top plate 13 and bottom plate 14 within which the plastic sheet is securely held. All four sides are held at once.

A mould is then driven up through the clamped sheet forming a seal. The mould is then vacuumed by conventional means to form the resulting mould. At the end of this complete product cycle the secondary clamp carriages 5 are returned to their initial positions by the action of the primary clamp bars. A series of linkages prevent the secondary clamps 5 from getting too close to each other.

The machine also provides zoned cooling for control of thickness distribution in the final product. This is a technique used in the prior art.

The entire process cycle involving both the timings and movements is controlled by a computer or controlled programme logic controller. As a result of this machine it becomes possible to make considerable savings in raw material costs; for example, experiments have indicated that savings of 30% - 50% can be readily achieved. This could not be achieved simply by vacuum forming a thinner sheet of thermoplastic as only the strength benefits

provided by the stretching step allow this lower volume of plastic to be used.

Figure 4 (a) shows a conventional method for cutting up a sheet of plastic that is 3100mm x 1800mm to form four rectangular pieces 1750mm x 750mm for use in making a product sized 1700mm x 700mm. Note that offcuts are left around the edge. Figure 4 (b) shows how this same sheet can be cut into six rectangular pieces 1550mm x 600mm without offcuts, that may be stretched then used to give a product sized 1700mm x 700mm as before.

This reduces the time required and the space requirements for storing raw material. Additionally, fewer different sizes of sheet will have to be stocked by a manufacturer. These benefits represent a substantial cut in the cost of manufacturing the product, therefore providing an important commercial advantage.

It will be clear to one skilled in the art that this technique can be used with acrylic plastic or any other vacuum formable material. Furthermore, this plastic stretching technique will find applications in areas other than just vacuum forming.

Further modifications and improvements may be incorporated without departing from the scope of the invention herein.

Throughout this application, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising" will be understood to imply the inclusion of a stated integer or group of integers

but not the exclusion of any other integer or group of integers.

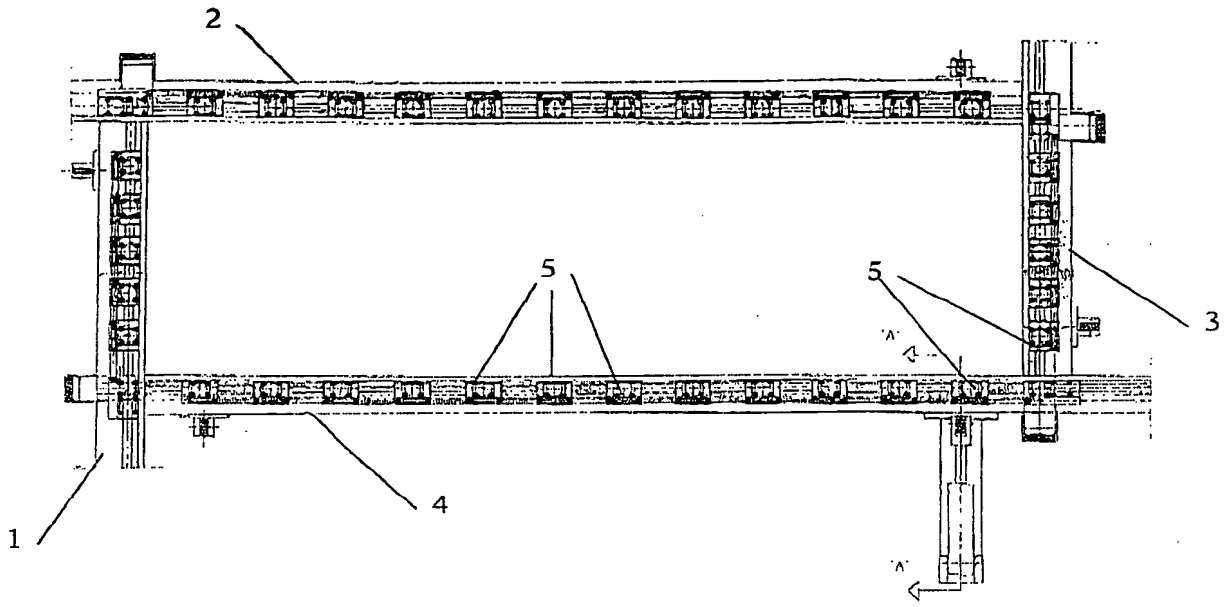


Figure 1

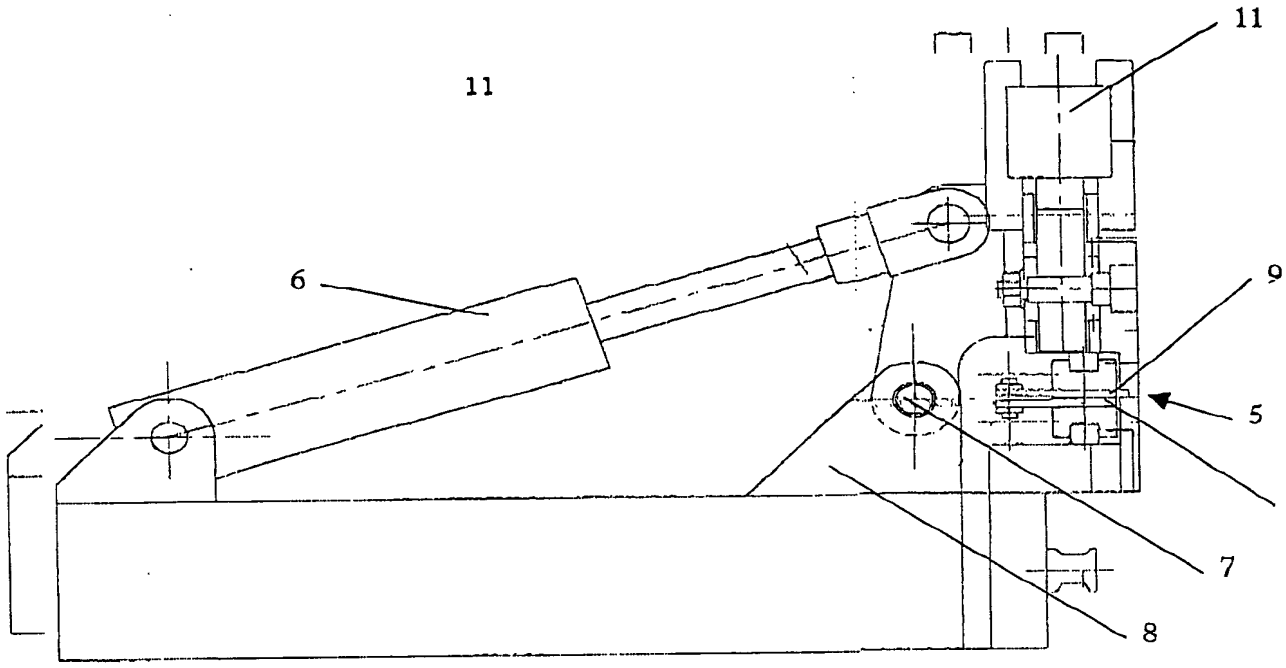


Figure 2

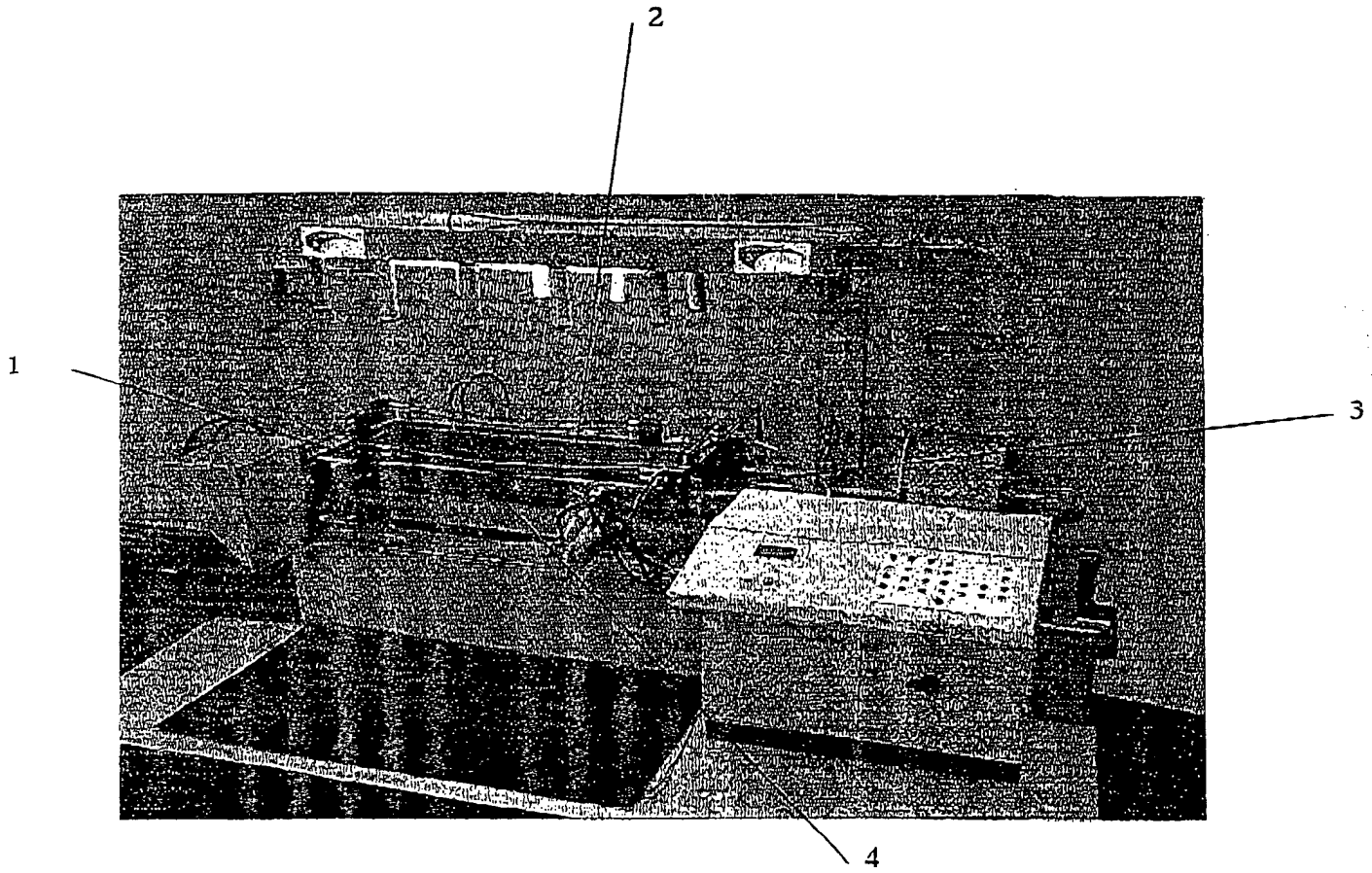
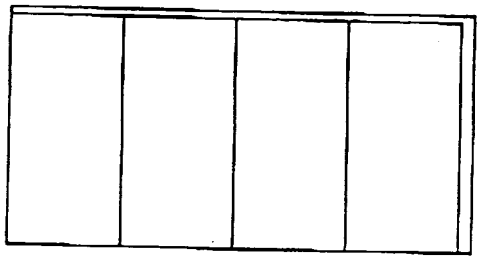
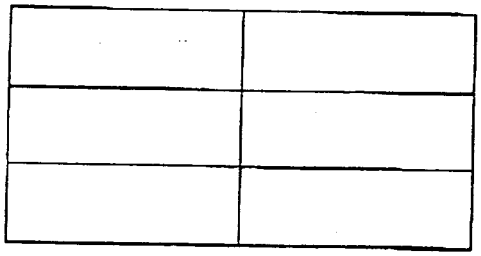


Figure 3



(a)



(b)

Figure 4

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Kennedy + Co